ALLOY 718 EXTRUSION MODELING—UNSTABLE FLOW AND MESH ENRICHMENT

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Alloy 718 is the most widely used superalloy for aerospace applications, and composes a remarkable 34 percent of finished component weight in the CF6 gas turbine engine. Applications include critical rotating parts, airfoils, supporting structures and pressure vessels [1]. Further, over 80% of the CF6 engine components include forming operations [1], and to minimize in-service failures, demonstration must be made of sufficient microstructural control over defects such as shear bands, undesirable grain size distributions, micro -porosity, shrinkage, cracks, etc. In addition, maintaining dimensional tolerances during forming is often critical for subsequent operations. Traditionally, forming process and die optimization has been performed on hard tooling, but increasingly, modeling and FEA simulation techniques are applied.

We outline efforts to predict the *onset* of shear bands and geometric deviations in the extrusion of Alloy 718. Shear bands are an unstable localization of intense plastic flow, and factors contributing to their formation during extrusion include microstructural factors (initial microstructure, dynamic recrystalization, dynamic recovery and dynamic precipitation behavior), processing factors (soaking temperature, dwell time, and induced gradients in temperature, stress, strain and strain rate) and their interplay (adiabatic heating). Instabilities are encountered when the contributors to flow softening overcome stabilizing factors. Because our focus is on preventing shear-band formation, the model is required only to predict the likelihood of localization, not to accurately depict the localization once formed. Present models employing process maps [2], used to chart regions of unstable processing conditions, are shown to be overly conservative as extrusion ratios, constraints on manufacturing equipment, and prior art dictate an aggressive process. A model has been developed based on empirical designed experiments. This model is sensitive to an accurate description of the material response and an accurate description of the temperature, strain and strain rate fields. In this regard, mesh updates and the management of discretization errors is critical to the modeling effort. We also outline efforts to couple the commercial finite element software code DEFORM3D with SCOREC mesh optimizations and error estimators. The SCOREC mesh enrichments, based on an *h*-adaptive procedure, employ a number of local mesh modification operators to minimize the mesh-associated errors (i.e. mesh discretization, element distortion and geometric approximation errors). An error estimator is constructed based on gradients of selected variables to produce the driver for adaptive mesh enrichments.

References

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